Engineering and Fabrication of the High Gradient Structure for Compact Ion Therapy LINAC

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Abstract:

RadiaBeam is fabricating a novel ultra-high gradient linear accelerator for the Advanced Compact Carbon Ion LINAC (ACCIL) project. The ACCIL is an Argonne National Laboratory (ANL) led project, in collaboration with RadiaBeam, designed to be capable of delivering sufficiently energized carbon ions and protons while maintaining a 50 m footprint. This is made possible by the development of S-Band 50 MV/m accelerating structures for particles with beta of 0.3 or higher. Such high gradient accelerating structures require particular care in their engineering details and fabrication process to limit the RF breakdown at the operating gradients. The details of fabrication and engineering design of the accelerating structure will be presented.

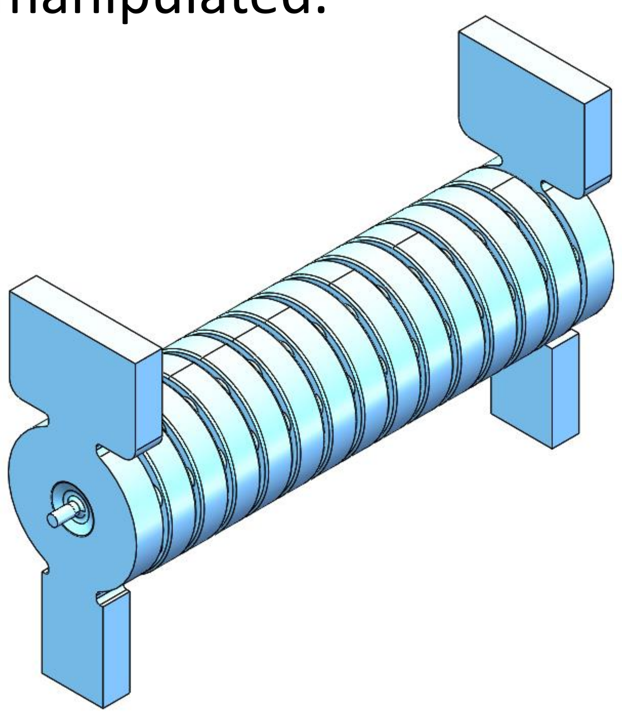
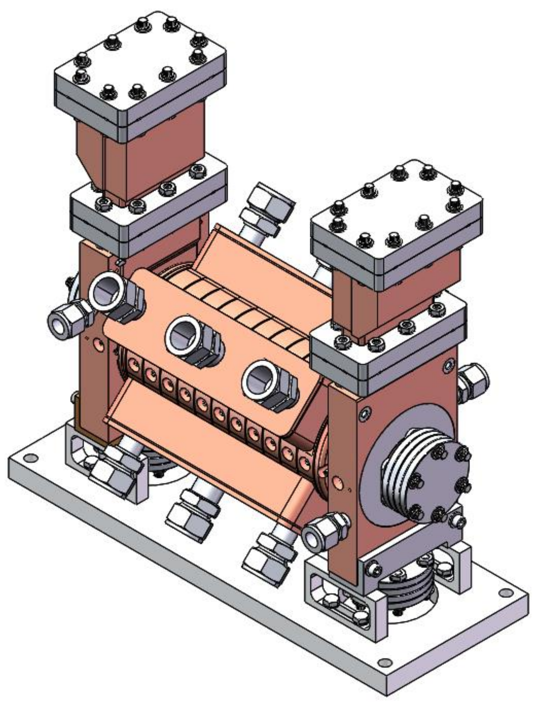
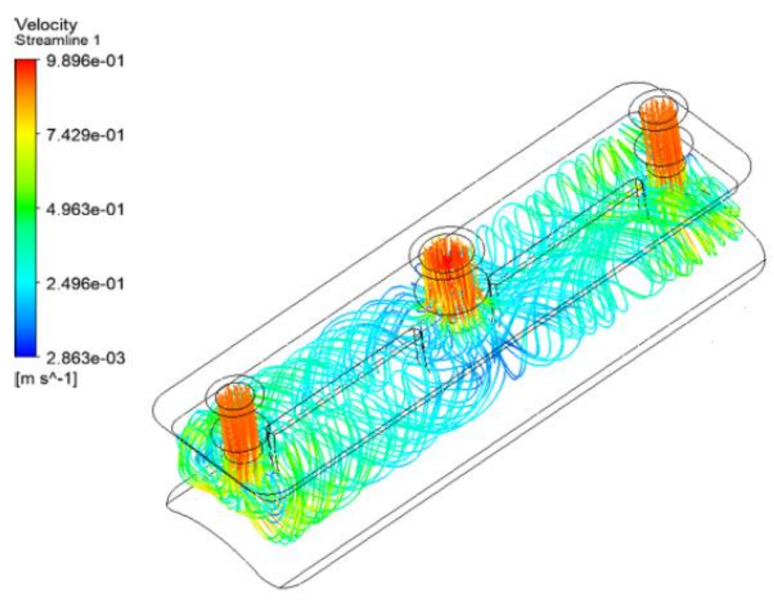
Engineering Design:

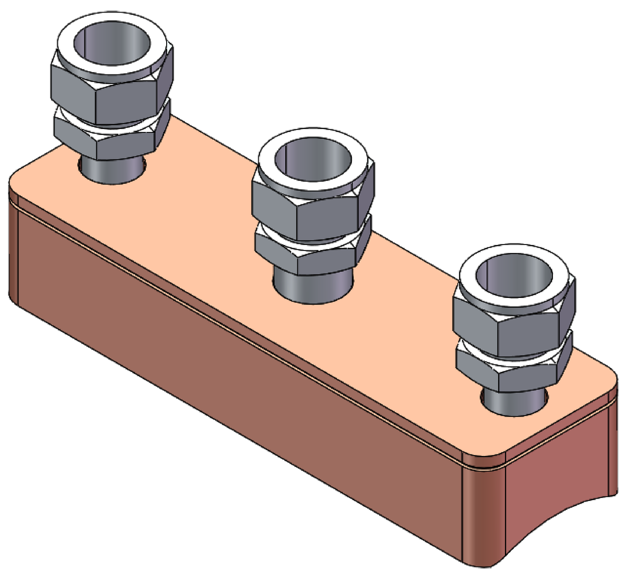
The ACCIL High Gradient Structure was designed based off of a 15 cell RF Profile. The final accelerator structure was designed around the vacuum profile with the intention of assembly through brazing. Mating features between cells and couplers feature a nominal gap of .0005" to hold the RF profile to specification. Clocking of cells was determined through tolerancing studies to be forgiving and will be executed by referring to external features.

Cells and couplers feature tuning ports used to house custom tuning pins. Tuning pins are used to manually deform the RF volume until the structure field profile is flat.

Cooling blocks were designed to keep this high average power structure below 65°C. The cooling blocks feature a central inlet and two outer outlets that allow for a more even cooling distribution across the structure. The cooling blocks were also designed to allow easy access to tuning pins and eliminate water to vacuum braze joints.

Custom tooling for brazing, leak testing, and bead pull tuning was also developed. Braze tooling was designed out of graphite to prevent undesired joining. Leak testing tooling was designed to check hermeticity between braze stages. Bead pull tuning was designed to stabile hold the structure as RF volume is manipulated.

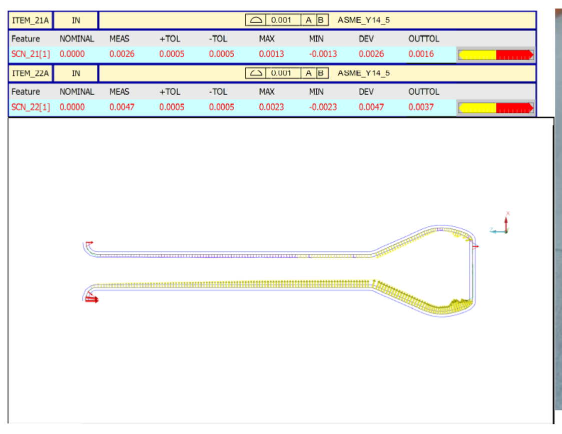
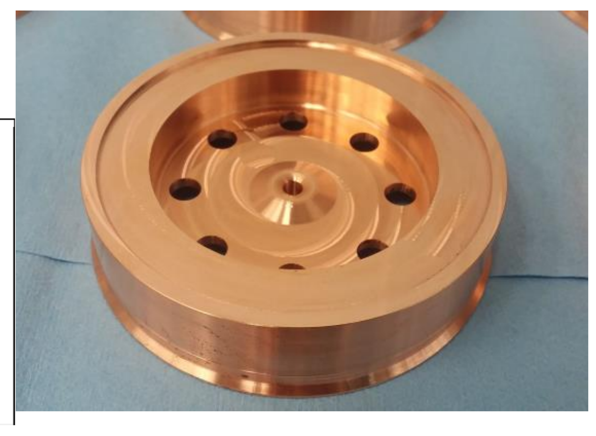


K. Sergey *et al.*, "Design of The High Gradient Negative Harmonic Structure for Compact Ion Therapy LINAC", LINAC 18, 2018.

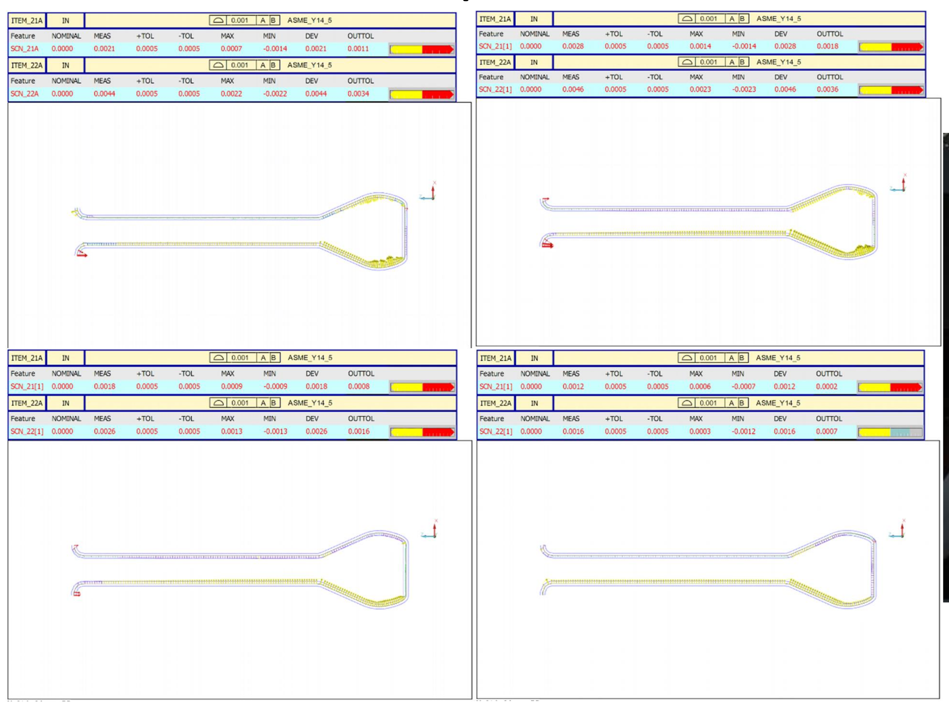
Fabrication:

Cell and coupler fabrication began with a variety of test to hone in machining practices and programs for manufacturing, with emphasis on achieving acceptable profile and surface finishes.

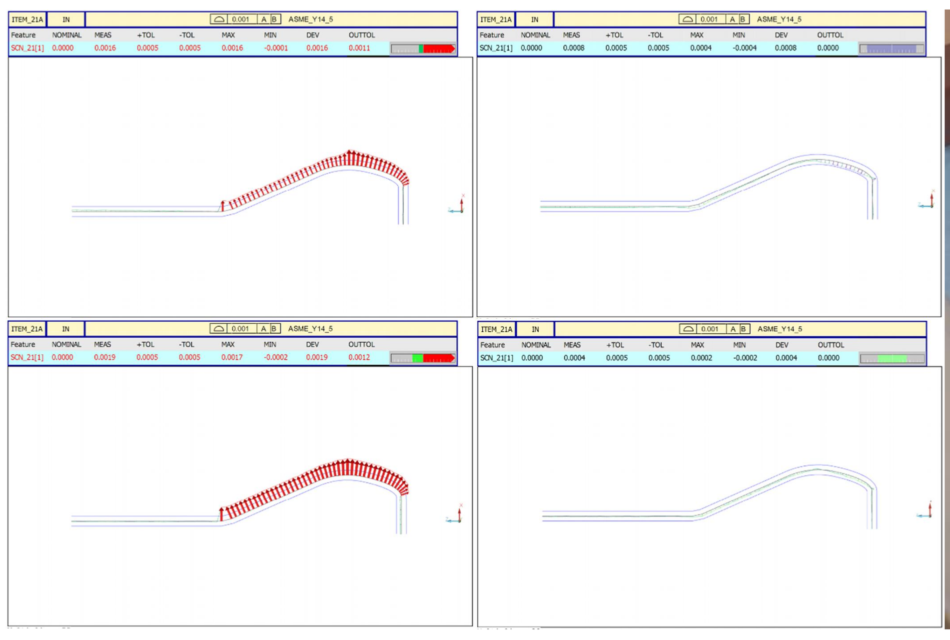
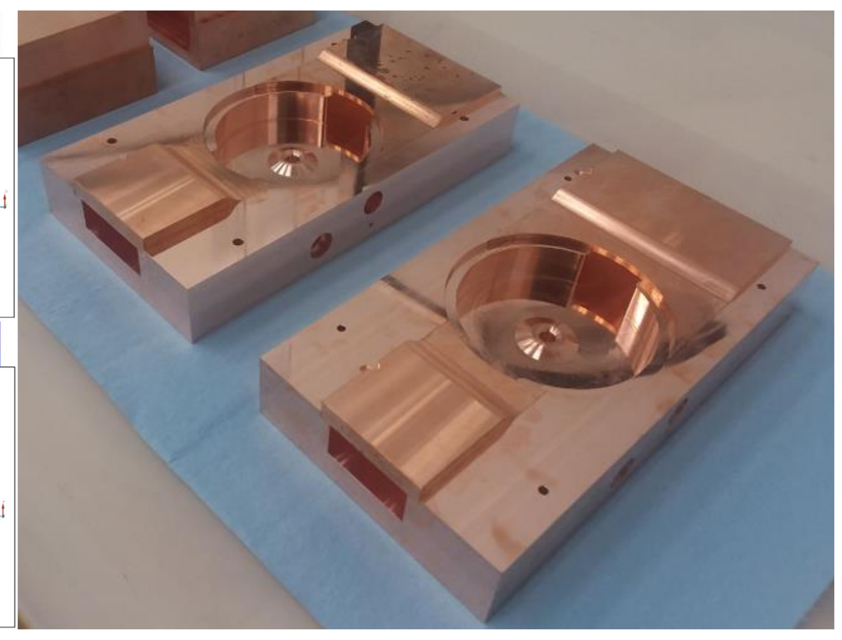
First cell produced had a noticeable sloped error due to universal blank design.

Clamping of the blank cell was done through an integrated dove tail. Clamping pressure applied to the dove tail during machining caused the main cell wall to bow due to lack of support material. A stainless steel disk was designed to fit in the cell to support part during clamping and machining. More tests were conducted and adjustments to the tool paths and feeds and speeds were done until an acceptable part was produced with accepted surface finish of Ra = 3-4 μin

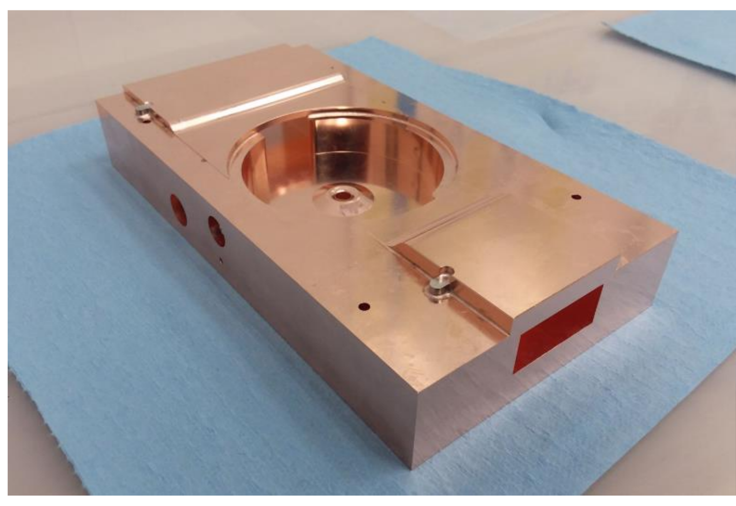
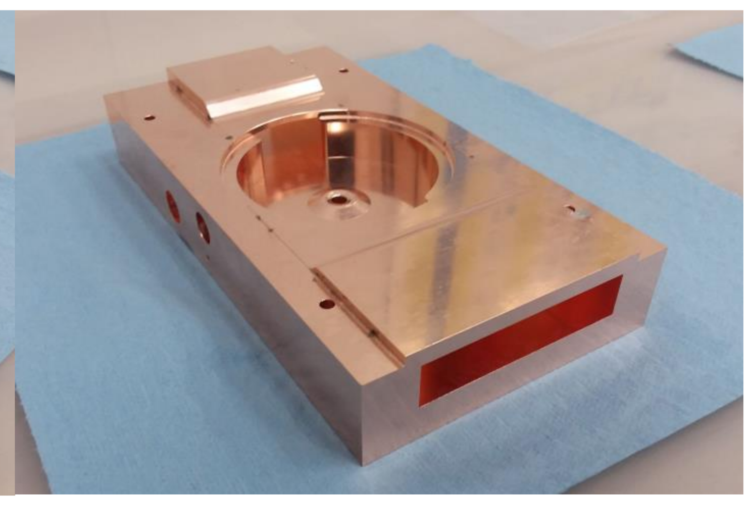



Couplers also needed feature prototyping. The surface profile and finish of the iris in the coupler bodies was tested until feature was successfully produced with an accepted surface finish of Ra = 6-8 μin.

Assembly:

The final structure will be vacuum brazed together in steps that will utilize 25% Au – 75% Cu, 35% Au – 65% Cu, and 50% Au – 50% Cu alloys. RF surfaces will be limited to four thermal cycles to prevent deterioration. Couplers have already gone through their first stage of brazing and post braze dry machining operations.

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